REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	28 Sep 98	Reprint

4. TITLE AND SUBTITLE
Recent Upgrades to MODTRAN - New Solar Irradiance and Instrument Scanning Functions

5. FUNDING NUMBERS
PE 63215C
PR S321
TA GD
WU BS
F19628-93-C-0049

6. AUTHOR(S)
P.K. Acharya, A. Berk, L.S. Bernstein, D.C. Robertson, G. Anderson*, J.H. Chetwynd*, H.E. Snell#, and J. Vail**

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Spectral Sciences, Inc.
99 South Bedford St., #7
Burlington, MA 01803-5169

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Research Laboratory/VSBM
29 Randolph Rd
Hanscom AFB, MA 01731-3010

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
AFRL-VS-HA-TR-98-0096

11. SUPPLEMENTARY NOTES
Reprinted from Proceedings of the 20th Annual Conference on Atmospheric Transmission Models, 10-12 June 1997
* Air Force Research Laboratory, Hanscom AFB, MA. # Atmospheric and Environmental Research, Inc., Cambridge, MA. ** MEI Techynologies, Lexington, MA.

12a. DISTRIBUTION AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
Recent upgrades are intended to make MODTRAN a more accurate, convenient and versatile atmospheric modeling tool. The current default solar irradiance database due to Kurucz was corrected in the 310-340 nm region using measured data. Several other data sets are also made available to the user. The user can also use his/her won data residing in a file. Examination confirms that the corrected Kurucz data is still the best overall among all currently available data sets. MODTRAN can now be run using frequency inputs which are in wavenumber, nm or micron. Additionally, there is now the capability of obtaining radiance and transmittance which are convolved with an apropriate instrument scanning function. Several choices of scanning functions are available including a user-defined option. This upgrade is helpful to users who would like to model satellite data which are gathered as a function of wavelength and have undergone instrument degradation. All upgrades are accompolished while maintaining strict compatibility of TAPE5 with earlier versions of the code. Work is currently in progress to incorporate NOVAM (Navy Oceanic Vertical Aerosol Models) into MODTRAN.

14. SUBJECT TERMS
Atmospheric radiance code
Radiance and transmittance
Vertical aerosol models
Solar irradiance data base
Instrument scanning function

15. NUMBER OF PAGES
20

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

ABSTRACT

RECENT UPGRADES TO MODTRAN - NEW SOLAR IRRADIANCE AND INSTRUMENT SCANNING FUNCTIONS

20th Annual Air Force Transmission Meeting
Phillips Laboratory/GPO
Hanscom AFB, MA 01731

P. K. Acharya, A. Berk, L. Bernstein and D. Robertson
Spectral Sciences, Inc.
99 S. Bedford Street, Suite No. 7
Burlington, MA 01803

G. Anderson and J. Chetwynd
Phillips Laboratory/GPO
Hanscom AFB, MA 01731

H. E. Snell
Atmospheric and Environmental Research, Inc.
Cambridge, MA

J. Vail
Mei technologies, Lexington, MA

Recent upgrades are intended to make MODTRAN a more accurate, convenient and versatile atmospheric modeling tool. The current default solar irradiance database due to Kurucz was corrected in the 310-340 nm region using measured data. Several other data sets are also made available to the user. The user can also use his/her own data residing in a file. Examination confirms that the corrected Kurucz data is still the best overall among all currently available data sets. MODTRAN can now be run using frequency inputs which are in wavenumber, nm or micron. Additionally, there is now the capability of obtaining radiance and transmittance which are convolved with an appropriate instrument scanning function. Several choices of scanning functions are available including an user-defined option. This upgrade is helpful to users who would like to model satellite data which are gathered as a function of wavelength and have undergone instrument degradation. All upgrades are accomplished while maintaining strict compatibility of TAPE5 with earlier versions of the code. Work is currently in progress to incorporate NOVAM (Navy Oceanic Vertical Aerosol Models) into MODTRAN.

RECENT UPGRADES TO MODTRAN - NEW SOLAR IRRADIANCES AND INSTRUMENT SCANNING FUNCTIONS

P. K. ACHARYA, A. BERK AND L. B. BERNSTEIN
Spectral Sciences, Inc., Burlington, MA

G.P. ANDERSON AND J.H. CHETWYND
Phillips Laboratory/GPOS, Hanscom AFB, MA

H.E. SNELL
Atmospheric and Environmental Research, Inc., Cambridge. MA

J. VAIL
Mei Technologies, Lexington, MA

THE 20TH ANNUAL DOD CONFERENCE ON ATMOSPHERIC TRANSMISSION MODELS (10-12 JUNE, 1997)

OUTLINE

- SOLAR IRRADIANCE UPGRADES
  - MOTIVATION
  - DESCRIPTION OF DATA SETS
- GENERALIZED FREQUENCY INPUT SCHEME
  - NEW UNITS FOR FREQUENCY INPUTS
- INSTRUMENT SCANNING OR FILTER FUNCTION CAPABILITY
  - DESCRIPTION OF SCANNING FUNCTIONS
- SUMMARY

MOTIVATION

- MODTRAN REQUIRES ACCURATE TOA SOLAR IRRADIANCE (I_0)
- CURRENTLY CALCULATIONS DUE TO KURUCZ ARE USED
  - EXTENSIVE LBL CALCULATIONS BASED ON SOLAR TEMPERATURE PROFILE, SOLAR ABUNDANCES AND VOIGT LINE PROFILE
  - STANDS UP WELL AGAINST MEASUREMENTS
- NEW MEASUREMENTS ARE AVAILABLE INCLUDING THOSE AT TOA
  - MEASUREMENTS AT KITT-PEAK (USED BY THE GOME COMMUNITY)
  - TOA SOLAR UV MEASUREMENTS (ATLAS SSBUV)
  - TOA MEASUREMENTS BY FRENCH SCIENTISTS (SOLSPEC)
- NEED TO ACCOMMODATE USER-SUPPLIED I_0
  - HAS APPLICATIONS, FOR EXAMPLE, IN O_3 RETRIEVAL

NEW CHOICES OF BUILT-IN I_0 FILES

- CARD 1A, COLUMNS 61-80, TRIGGERS CHOICE OF I_0
- FOUR BUILTIN SOLAR I_0 FILES
  - NEWKUR.DAT (CORRECTED KURUCZ); INPUT 1 OR BLANK
  - OLDKUR.DAT (KURUCZ); INPUT 2
  - CHKUR.DAT (KITT-PEAK, COURTESY OF K. CHANCE); INPUT 3
  - CEBCHKUR.DAT (ATLAS SSBUV, COURTESY OF R. CEBULA); INPUT 4
  - THKUR.DAT (SOLSPEC, COURTESY OF G. THUILLIER); INPUT 5
- CORRECTED KURUCZ IS DEFAULT (BLANKS IN COLS 61-80)
- ALL ARE FROM 50-50000 CM^{-1}; NON-KURUCZ HAVE MULTIPLE SOURCES
  - IRRADIANCES IN $(W/CM^2)/CM^{-1}$ VERSUS CM^{-1}
- USER-SUPPLIED DATA CAN BE USED (FILENAME IN COLS 61-80)

STRUCTURE OF USER-SUPPLIED I_0 FILE

- FILE CONTENT

FREQUENCY UNIT DESIGNATOR	IRRADIANCE UNIT DESIGNATOR
FREQUENCY 1	IRRADIANCE 1
FREQUENCY 2	IRRADIANCE 2
...	...

- UNIT DESIGNATORS

1	FREQUENCY IN CM^{-1}	I_0 IN $(W/CM^2)/CM^{-1}$
2	FREQUENCY IN NM	I_0 IN $(PHOTONS/S)/CM^2$
3	FREQUENCY IN MM	I_0 IN $(MILLIWATTS/M^2)$/NM OR $(W/M^2)/\mu M$ (NUMERICALLY IDENTICAL)

- I_0 AT INTEGRAL CM^{-1}, ARE OBTAINED BY INTEGRATION/INTERPOLATION

- PADDED BY DATA FROM DEFAULT BUILTIN FILE

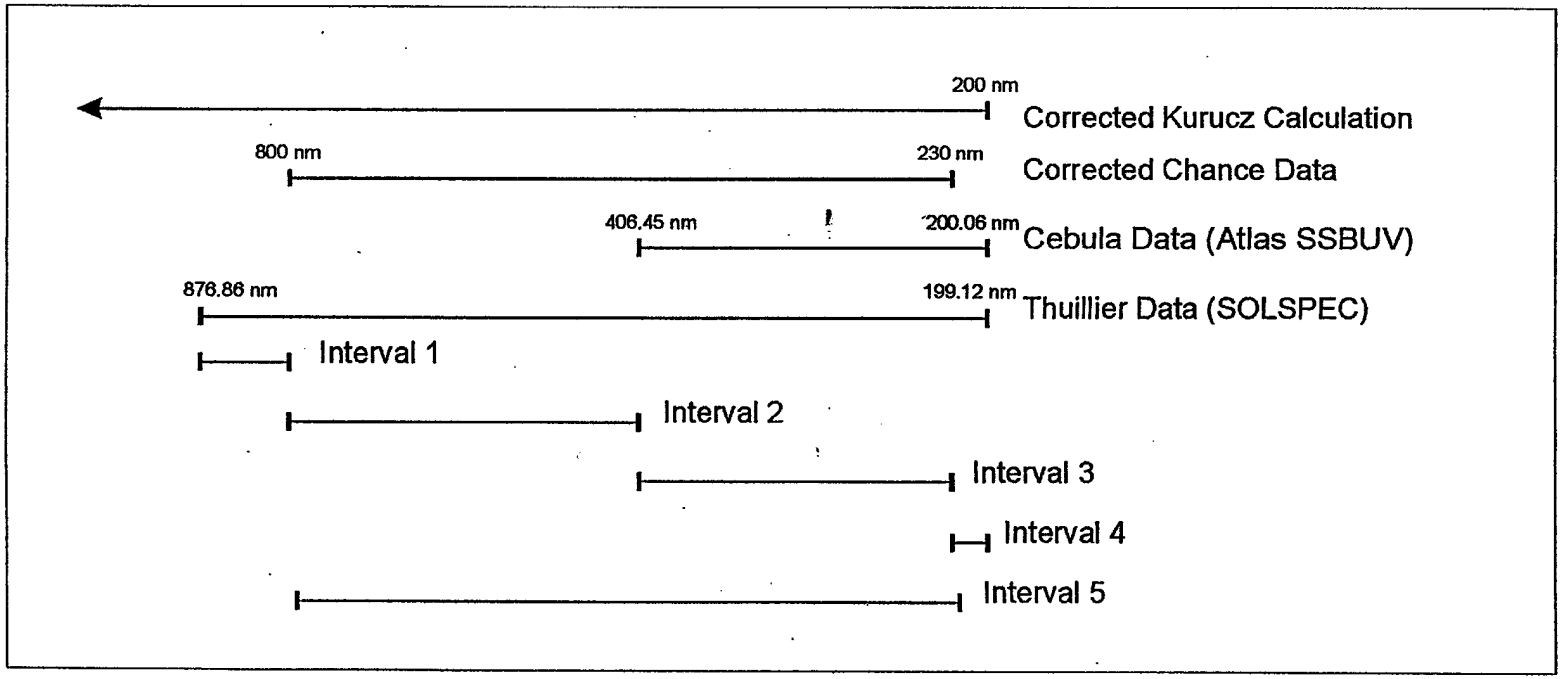
UPPER ATMOSPHERIC (SHUTTLE EXPT) DATA

- ATLAS SSBUV DATA; 200.06-406.45 NM (49985-24603 CM^{-1})
  - STEP SIZE 0.152-0.136 NM
  - UNCERTAINTY IN $\lambda \pm 0.026$ NM
  - 2σ UNCERTAINTY 6% AT 200 NM, 2.8% AT 250 NM AND 2.6% 300-400 NM
- SSBUV WAS AUGMENTED BY KITT-PEAK DATA AND KURUCZ
- SOLSPEC INSTRUMENT; 199.12-876.86 NM (11404-50221 CM^{-1})
  - STEP SIZE 0.36-0.9 NM
- SOLSPEC SET WAS BY AUGMENTED BY KURUCZ CALCULATION
- ATLAS SSBUV IS TAKEN TO BE THE BENCHMARK FOR THIS TASK

KITT-PEAK MEASUREMENTS DATA

- TWO SETS OF MEASUREMENTS MERGED (230-800 NM)
  - CALIBRATION IS ± 0.002 NM, STEP SIZE IS 0.01
- DATA WAS NOT CORRECTED FOR O_2 ATMOSPHERIC BAND LINES
  - REPLACED O_2 LINES BY KURUCZ'S
- SOME ATMOSPHERIC EFFECTS STILL REMAIN
  - AROUND 720 NM ATMOSPHERIC H_2 MAY BE A PROBLEM
  - AROUND 320-330 NM THERE IS ALSO SOME PROBLEM

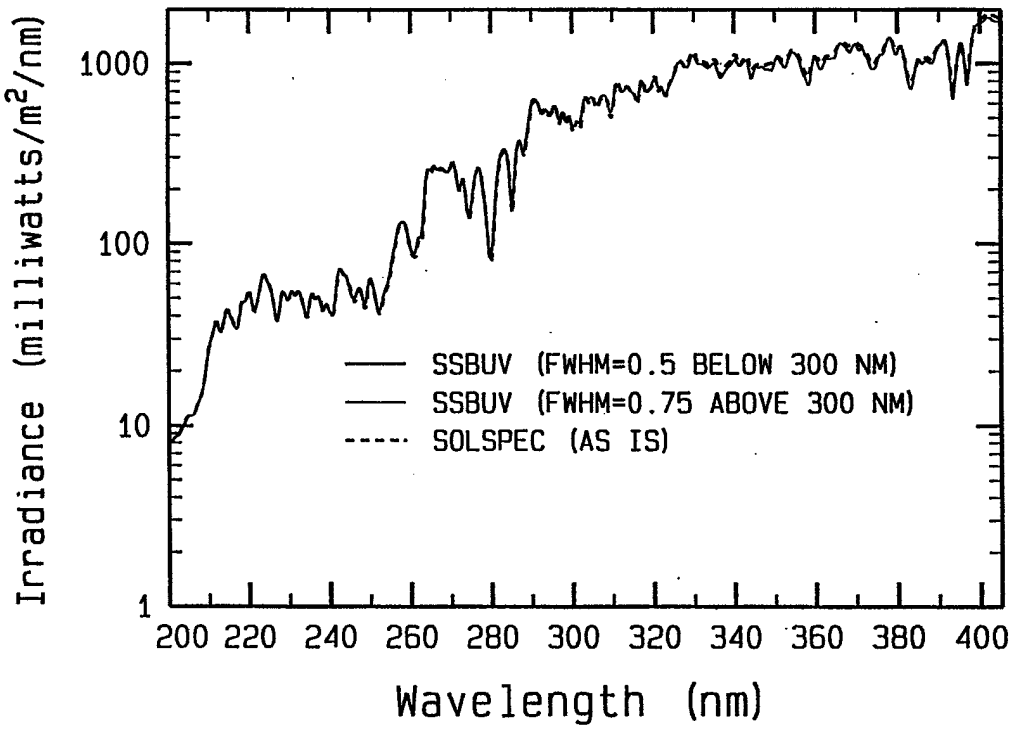
INTEGRATED BANDPASS RADIANCES (W/m²)



	877-800 nm Interval 1	800-406 nm Interval 2	406-230 nm Interval 3	230-200 nm Interval 4	800-230 nm Interval 5
KR 80		647	122	0.95	768
CH		645	118		764
CB			121	1.02	
TH 82		654	124	1.02	778

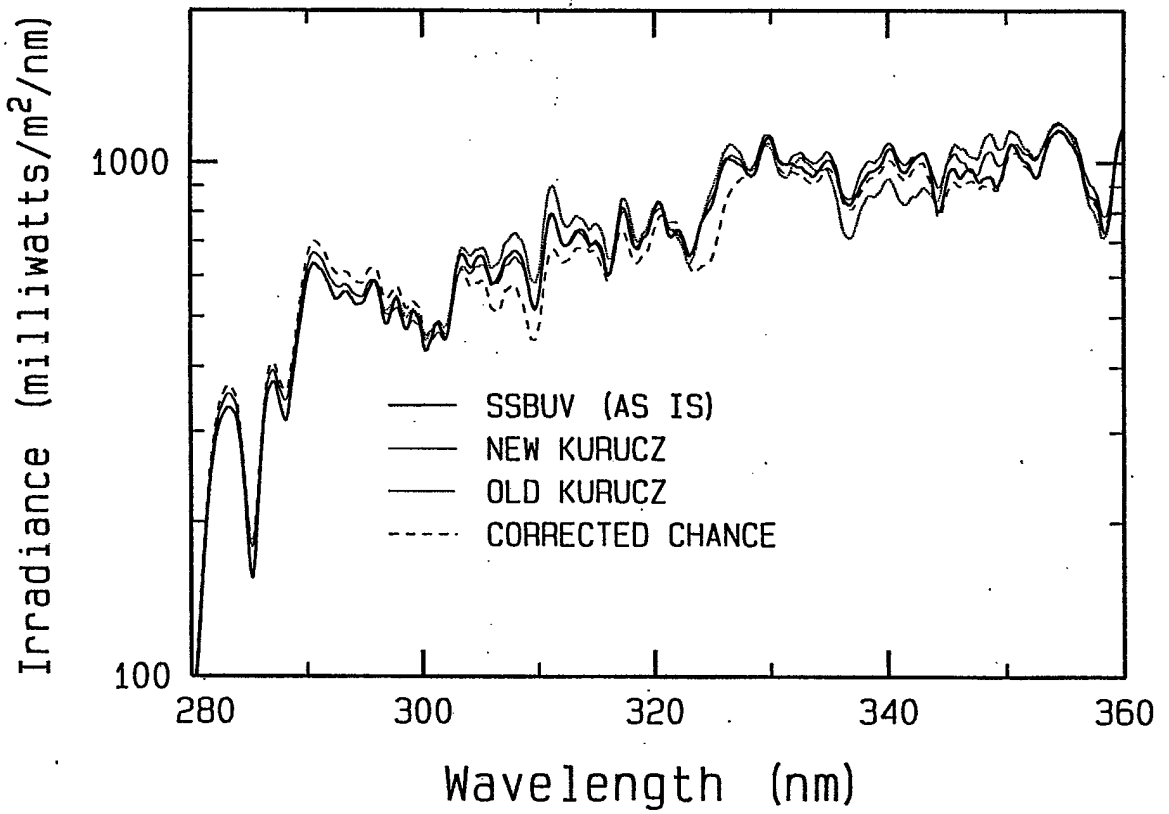
(KR = corrected Kurucz, CH = corrected Chance, CB = SSBUV, TH = SOLSPEC)

UPPER ATMOSPHERIC DATA COMPARED

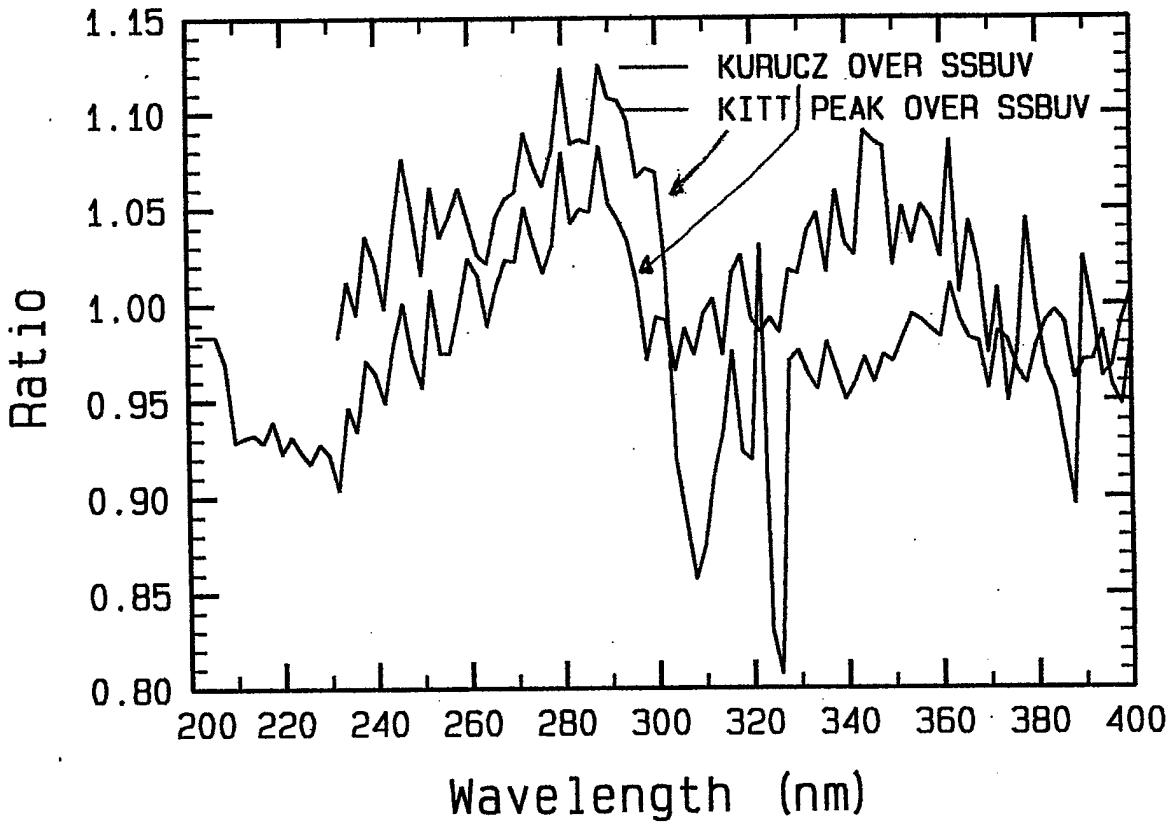


- SSBUV AND SOLSPEC COMPARED AT "COMMON" RESOLUTION
- MAXIMUM DIFFERENCE IS 11% AT 263 NM
- AGREEMENT IS BETTER AT SHORTER WAVELENGTHS

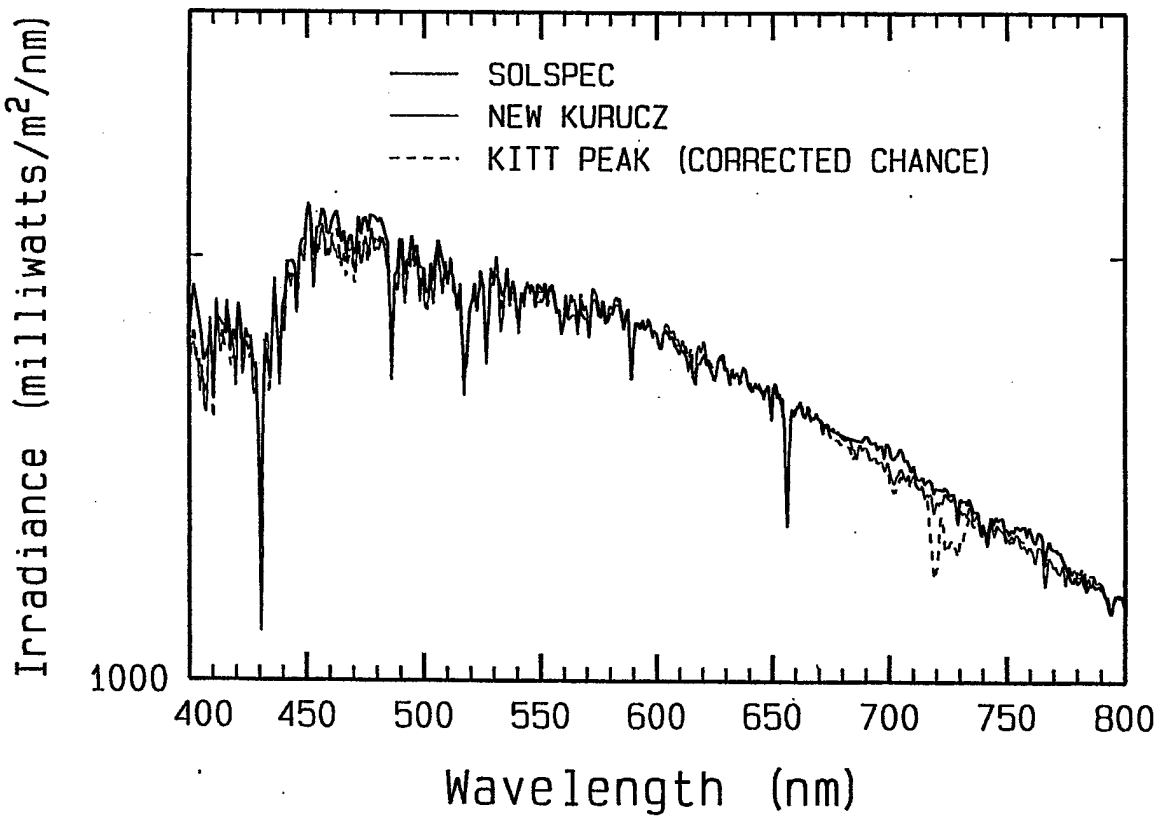
KITT-PEAK AND CORRECTED KURUCZ (310-340 NM)



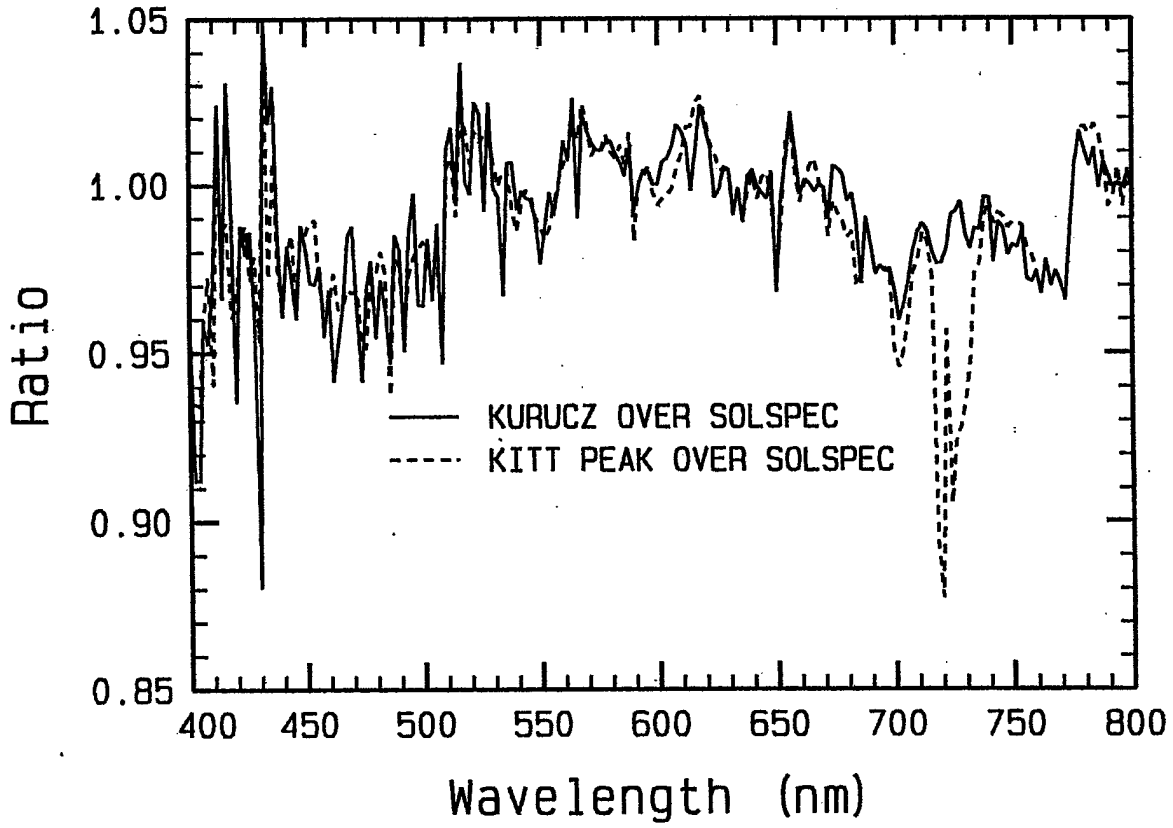
KITT-PEAK AND CORRECTED KURUCZ (200-400 NM)



KITT-PEAK AND CORRECTED KURUCZ (400-800 NM)



KITT-PEAK AND CORRECTED KURUCZ (200-400 NM)



GENERALIZED UNITS FOR CARD 4 INPUTS

CARD 4: V1, V2, DV, FWHM, YFLAG, XFALG, DLIMIT, FLAGS
FORMAT(4F10.0, 2A1, A8, A4)

- FREQUENCY INPUTS CAN NOW BE IN μM, NM AND CM^{-1}
- UNIT IS INDICATED BY FLAGS(1:1) WHICH IS W, M, N OR BLANK
- DEFAULT (FLAGS(1:1) IS BLANK) IS CM^{-1}
- OLD TAPE5's WORK JUST FINE WITH THE NEW CODE

INSTRUMENT SCANNING FUNCTION

- CHOICE IS INDICATED BY FLAGS(2:2)

1 TRIANGULAR	2 SQUARE	3 GAUSSIAN
4 SINC	5 $SINC^2$	6 HAMMING
7 USER-SUPPLIED		

- DEFAULT (BLANK) IS TRIANGULAR; OLD TAPE5's ARE FINE

- FLAGS(3:3) INDICATES IF FWHM IS RELATIVE
  - RELATIVE % FWHM CAN HELP MODEL, E.G., CVFs

- CAN ONLY DEGRADE TOTAL TRANS AND RAD TO SAVE TIME
  - MUST SET FLAGS(4:4) TO BLANK

- IF FWHM IS TOO FINE ERROR MSG IS PRINTED AT THE OUTSET

NEW OUPUTFILES

- PLOTOUT.SCN AND TAPE7.SCN

SUMMARY OF MODTRAN UPGRADES

- SEVERAL CHOICES OF SOLAR I_0 DATA IS AVAILABLE
- THE KURUCZ SPECTRUM (CORRECTED IN 310-340 NM) IS STILL THE BEST (DEFAULT)
- USER-DEFINED I_0 FILE WITH FLEXIBLE UNITS CAN BE INPUT
- CARD 4 INPUTS CAN BE IN μM, NM OR CM^{-1}
- SEVERAL SCANNING FUNCTIONS (INCLUDING USER-DEFINED FUNCTION) ARE NOW AVAILABLE